BS EN 16402:2013

BSI Standards Publication

Paints and varnishes — Assessment of emissions of substances from coatings into indoor air — Sampling, conditioning and testing

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National foreword

This British Standard is the UK implementation of EN 16402:2013.

BSI, as a member of CEN, is obliged to publish EN 16402 as a British Standard. However, attention is drawn to the fact that the UK committee voted against its approval as a standard in CEN. The UK committee voted against this standard because the information and guidance given in Annex B relating to very volatile organic compounds (VVOCs) is less substantial than that which was issued for CEN Enquiry. For this reason, a negative vote was submitted.

The UK participation in its preparation was entrusted to Technical Committee STI/10, Test methods for paints.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Paints and varnishes - Assessment of emissions of substances from coatings into indoor air - Sampling, conditioning and testing

Peintures et vernis - Évaluation des émissions de substances émanant des revêtements dans l'air intérieur - Échantillonnage, conditionnement et essais

Beschichtungsstoffe - Bestimmung der Emissionen regulierter gefährlicher Stoffe von Beschichtungen in die Innenraumluft - Probenahme, Probenvorbereitung und Prüfung

This European Standard was approved by CEN on 24 August 2013.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 16402:2013) has been prepared by Technical Committee CEN/TC 139 “Paints and varnishes”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2014, and conflicting national standards shall be withdrawn at the latest by April 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard refers to the horizontal method (see CEN/TS 16516) for emission testing of construction products (developed in according to the Mandate M/366) and specifies the product specific details for architectural coatings and the product categories described in Clause 5.

The Construction Products Regulation (CPR) covers only coatings that are of influence to the construction and does not include architectural coatings.

Both CPR covered coatings and architectural coatings not covered by CPR may be tested according to this European Standard.

The determination of emission into indoor air is to be made under the conditions of use during the service life. The determination of emissions specified in this European Standard is associated with an emission scenario which specifies the climate and ventilation conditions of the air surrounding the product in a reference room. It is not applicable for the determination of emissions during the application.

A reference room is needed since it is not possible to evaluate emissions by testing in all possible use situations. The reference room dimensions and the resulting loading factors, the climate and ventilation conditions are the reference representing the general indoor air conditions. Based on the huge amount of available European experience, it was possible to identify one emission scenario and one reference room including a set of loading factors to be used.

This method is using a test chamber in which emissions are generated under conditions maintained constant during the test. These conditions are selected so that the results could be expressed either as emission rates or converted to concentrations in the reference room by calculations within the ranges where such calculations are valid.

This European Standard also addresses separately (see Clause 14 and informative Annex A) the simplified test methods, indirect test methods, secondary/alternative test methods that provide within their specific field of application a result comparable or correlated to the result of the reference method. Such methods can be easier to apply and/or cheaper. They can be used especially for Factory Production Control testing (FPC).

The aim of this European Standard is not to develop a new testing method but to combine by normative references the use of existing standards complemented, when necessary, with additional and/or modified requirements so that architectural coatings can be evaluated under comparable conditions with regard to emission into indoor air.

In particular, the horizontal test methods for emission testing of construction products (see CEN/TS 16516) as developed regarding to Mandate M/366 have been considered and will be taken into account for further revisions of this European Standard to ensure that comparable methods are applied for construction products as defined in Mandate M/366 and coatings covered by this European Standard.

1 Scope

This European Standard specifies a reference method for the determination of emissions from coatings into indoor air. This method is applicable to volatile organic compounds, semi-volatile organic compounds and volatile aldehydes.

NOTE This European Standard is aimed at describing the overall procedure and makes use of existing standards mainly by normative reference complemented when necessary with additional or modified normative requirements.

This European Standard applies to coatings for indoor use as listed in Clause 5.It is not applicable to coatings that are applied off site or coatings that are applied on site, prior to the structure being permanently weatherproof. It is not applicable for tinting pastes that are not ready for use as coating.

It is mainly aimed at determining emission data in indoor air for the purpose of voluntary labelling of products but may also be used for CE marking and associated Attestation of Conformity in the case of products that are covered by the Construction Products Regulation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1232, *Workplace atmospheres - Pumps for personal sampling of chemical agents - Requirements and test methods*

EN 13300, *Paints and varnishes - Water-borne coating materials and coating systems for interior walls and ceilings - Classification*

EN 15824, *Specifications for external renders and internal plasters based on organic binders*

EN ISO 16000-9:2006, *Indoor air - Part 9: Determination of the emission of volatile organic compounds from building products and furnishing - Emission test chamber method (ISO 16000-9:2006)*

EN ISO 16000-11:2006, *Indoor air - Part 11: Determination of the emission of volatile organic compounds from building products and furnishing - Sampling, storage of samples and preparation of test specimens (ISO 16000-11:2006)*

EN ISO 16017-1, *Indoor, ambient and workplace air - Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography - Part 1: Pumped sampling (ISO 16017-1)*

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 16000-3:2011, *Indoor air — Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air — Active sampling method*

ISO 16000-6:2011, *Indoor air — Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Terms relating to sampling and product

3.1.1

sampling plan

predetermined procedure for the selection, withdrawal, preservation and transportation of product samples

Note 1 to entry: For the description of sampling plan, see CEN/TR 16220.

3.1.2

sample

portion of material selected from a larger quantity of material

[SOURCE: IUPAC:1997, 2.1.1]

Note 1 to entry: It is helpful to describe the manner of selection of the sample in a sampling plan.

Note 2 to entry: The term “sample” is often accompanied by a prefix (e.g. laboratory sample, test sample, test specimen) specifying the type of sample and/or the specific step in the sampling process to which the obtained material relates.

3.1.3

laboratory sample

sample or sub-sample(s) sent to or received by the laboratory

[SOURCE: IUPAC:1997, 2.5.5]

Note 1 to entry: When the laboratory sample is further prepared by mixing, drying, grinding or by combinations of these operations, the result is the test sample. When no preparation of the laboratory sample is required, the laboratory sample is the test sample. A test portion is removed from the test sample for the performance of the test/analysis or for the preparation of a test specimen.

Note 2 to entry: The laboratory sample is the final sample from the point of view of sample collection but it is the initial sample from the point of view of the laboratory.

3.1.4

curing

hardening of freshly prepared mixtures under well-defined conditions (time, temperature, humidity, etc)

3.1.5

curing time

minimum time necessary for curing before an emission test will produce meaningful test results

3.2 Terms relating to emissions into indoor air and associated laboratory testing

3.2.1

emission

liberation of chemical substances from a product into air

Note 1 to entry: Emission may be expressed as an emitted quantity in terms of concentrations in a defined volume of air or in terms of emission rate per hour and per unit quantity of the product (i.e. per area, length, mass, volume, unit or component).

Note 2 to entry: The terms “emission” and “release” have fundamentally the same meaning. However, by tradition, the term “emission” is used when describing liberation of chemical substances or radiation into air and the term “release” is used when describing the liberation of chemical substances into soil or water.

3.2.2
emission test chamber

enclosure with controlled operational parameters for the determination of volatile organic compounds emitted from products

[SOURCE: EN ISO 16000-9:2006, 3.6]

3.2.3
intended conditions of use

conditions that a product can experience during service life and that influence its release/emission behaviour

Note 1 to entry: These conditions are expressed in parameters such as temperature, amount of water during exposure, wetting/drying; intended conditions of use can vary for instance as a function of time, location, orientation, geographical location, etc. For simplification, intended conditions of use are transferred into release scenarios for test purposes.

3.2.4
test sample

sample, prepared from the laboratory sample, from which test portions are removed for testing or for analysis

[SOURCE: IUPAC:1997, 2.5.6]

3.2.5
test portion

quantity or volume removed from the test sample for analysis purposes, generally of known weight or volume

[SOURCE: IUPAC:1997, 2.5.7]

3.2.6
product loading factor

ratio of exposed surface area of the test specimen and the free emission test chamber volume

[SOURCE: EN ISO 16000-9:2006, 3.8]

Note 1 to entry: The product loading factor is often expressed as the ratio of the exposed area of the test specimen and the volume of the test facility (L_A expressed in m²/m³). The product loading factor can also be expressed as ratio of the exposed length, volume or unit(s) of the test specimen and the volume of the emission test facility (L_L expressed in m/m³, L_V expressed in m³/m³ or L_U expressed in u/m³).

3.2.7
test specimen

part of the sample specially prepared for emission testing in an emission test chamber in order to simulate the emission behaviour of the material or product that is tested

[SOURCE: EN ISO 16000-9:2006, 3.13]

3.2.8
air flow rate
ventilation rate

air volume entering into the emission test chamber per unit of time

[SOURCE: EN ISO 16000-9:2006, 3.2 modified – the synonym **ventilation rate** is added]

Note 1 to entry: Air flow rate is expressed in litres per second or in cubic metres per hour (l/s, m³/h).

3.2.9
air change rate

ratio of the volume of clean air brought into the emission test chamber per hour and the free emission test chamber volume measured in identical units

[SOURCE: EN ISO 16000-9:2006, 3.1]

3.2.10
specific air flow rate

q

ratio of air change rate and product loading factor

Note 1 to entry: Specific air flow rate can be expressed as the area specific air flow rate q_A, equivalent to ratio of the air flow rate and the surface area of the test specimen in $[m^3/m^2 \cdot h]$, which is equivalent to the expression [m/h].

Note 2 to entry: This definition includes other specific air flow rates than only the area specific air flow rate. Specific air flow rates can also be volume specific (q_v expressed in $m^3/(m^3 \cdot h)$), length specific (q_L expressed in $m^3/(m \cdot h)$), mass specific (q_m expressed in m3/(kg · h)), or unit specific (q_u expressed in $m^3/(unit \cdot h)$).

3.2.11
emission test chamber concentration

mass concentration of a specific volatile organic compound, VOC, (or group of volatile organic compounds) in test chamber air measured in the emission test chamber outlet

[SOURCE: EN ISO 16000-9:2006, 3.7, modified – the word mass is added before concentration, VOCx has been changed to VOC and the concentration of VOC has been related explicitly to test chamber air]

3.2.12
reference room

room with conventional dimensions, climate and ventilation used as reference for any specification of emission testing and any calculation of VOC concentration in indoor air

3.2.13
mass concentration of the compound in the reference room air

mass concentration of a specific volatile organic compound, VOCs, (or group of volatile organic compounds) in a reference room

3.2.14
specific emission rate
SER (emission factor)

product specific rate describing the mass of a volatile organic compound emitted from a product per time at a given time from the start of the test

[SOURCE: EN ISO 16000-9:2006, 3.11 modified – Q_m has been deleted; SER (emission factor) has been added]

Note 1 to entry: This definition is intended to help avoid confusion between the terms q (in 3.2.10) and q (used for specific air flow rate in ISO 16000-9). The specific emission rate can be related to area, length, volume, mass or unit, expressed as SER_A in $\mu g/(m^2 \cdot h)$, SER_L in $\mu g/(m \cdot h)$, SER_V in $\mu g/(m^3 \cdot h)$, SERm in µg/(kg · h), or SER_U expressed in µg/(u · h).

3.2.15
chamber blank value

test result obtained by carrying out the test procedure in the absence of a test specimen

Note 1 to entry: Blank value is expressed in micrograms per cubic metre ($\mu g/m^3$).

3.2.16
recovery

measured mass of a target volatile organic compound in the air leaving the emission test chamber during a given time period divided by the mass of target volatile organic compound added to the emission test chamber in the same time period, expressed in percent

[SOURCE: EN ISO 16000-9:2006, 3.9]

Note 1 to entry: The recovery provides information about the performance of the entire method.

3.3 Terms relating to determination of emitted substances

3.3.1
volatile organic compounds
VOC

all volatile organic compounds eluting between and including n-hexane and n-hexadecane on a gas chromatographic column as specified in 11.2.2

Note 1 to entry: The measurement is carried out using a capillary column coated with 5 % phenyl/95 % methyl-polysiloxane.

Note 2 to entry: This definition corresponds to volatile organic compounds with a boiling point in the range of approximately 68 °C to 287 °C.

Note 3 to entry: Other definitions are given by the World Health Organization (WHO) 1987, ISO 16000-6, Decopaint Directive 2004/42/EC, ISO 4618 and other sources.

3.3.2
total volatile organic compounds
TVOC

sum of the concentrations of the identified and unidentified volatile organic compounds eluting between and including n-hexane and n-hexadecane on a gas chromatographic column as specified in 11.2.2

[SOURCE: EN ISO 16000-9:2006, 3.2, modified – the following was added to the definition: on a gas chromatographic column as specified in 11.2.2]

Note 1 to entry: The measurement is carried out using a capillary column coated with 5 % phenyl/95 % methyl-polysiloxane.

3.3.3
semi-volatile organic compounds
SVOC

all organic compounds which, in a capillary column as specified in 11.2.2, are eluting with a retention range between n-hexadecane (excluded) and n-docosane (included)

Note 1 to entry: The measurement is carried out using a capillary column coated with 5 % phenyl/95 % methyl-polysiloxane.

Note 2 to entry: This definition corresponds to volatile organic compounds with a boiling point higher than approximately 287 °C.

Note 3 to entry: Other definitions are given by the World Health Organization (WHO) 1987, ISO 16000-6.

3.3.4
total semi-volatile organic compounds
TSVOC

sum of the concentrations of the identified and unidentified volatile organic compounds eluting with a retention range between n-hexadecane (excluded) and n-docosane (included) on a gas chromatographic column as specified in 11.2.2

Note 1 to entry: The measurement is carried out using a capillary column coated with 5 % phenyl/95 % methyl-polysiloxane.

3.3.5
very volatile organic compounds
VVOC

all volatile organic compounds eluting before n-hexane on a gas chromatographic column as specified in 11.2.2

Note 1 to entry: This definition corresponds to volatile organic compounds with a boiling point lower than approximately 68 °C.

Note 2 to entry: Other definitions are given by the World Health Organization (WHO) 1987, ISO 16000-6.

3.3.6
target compound

compound for which the result is compared with a compound specific limit value

3.3.7
non-target compound

compound for which the result is not compared with a compound specific limit value

3.3.8
limit value

numerical limit derived from national, European or contractual provisions

EXAMPLE National or European *LCI* values or classification values.

3.3.9
LCI value
Lowest Concentration of Interest

substance-specific value for health-related evaluation of the emission from products

3.3.10
R_i value

ratio C_i / LCI_i, where

— C_i is the chamber mass concentration of compound i;

— LCI_i is the LCI value of compound i

3.3.11
R value

sum of all R_i values

4 Principle

This European Standard combines by normative references the use of existing standards complemented, when necessary, with additional and/or modified requirements for the determination of emissions from coatings into indoor air.

This European Standard is not applicable to determine the emissions from a liquid or paste product during its drying and/or curing period. In this European Standard, emissions of volatile components emitted from the dried and/or cured coating into the vapour-phase are determined in time intervals. For this purpose, the following definitions apply:

- the intended use of the coating as defined in Clause 5;
- the emission scenario which specifies the typical dimensions of the reference room, the climate and ventilation conditions of the air surrounding the product according to Clause 7;

NOTE 1 It is not possible to evaluate emissions by testing in all possible use situations.

- the test chamber of the reference method according to Clause 10 in which emissions are generated under conditions that are kept constant during the test. These conditions are selected in the way that the results can be expressed directly in terms of vapour concentration in the reference room so that they can be converted for calculations according to Clause 12;
- the definition of sampling times for the emitted volatile compounds in the test chamber. These time intervals are intended to give representative results for the long term emissions of the tested coating at the service time and intended use.

This European Standard also specifies requirements and gives examples of simplified test methods, indirect test methods or secondary/alternative test methods (see Clause 14) that provide within their specific field of application a result which correlates with the result of the reference method. Such methods can be easier to apply and/or cheaper.

NOTE 2 In EN ISO 16000-9 the specifications regarding the dimensions of the reference room are informative (i.e. left to the choice of the user). In this European Standard they are normative in order to provide comparability. Furthermore, the preparation of test specimen from liquid samples is not defined in the normative part of EN ISO 16000-9.

5 Product categories

Only coatings and coating systems that are applied on-site and after the structure has been permanently weatherproofed shall be tested according to this European Standard.

The following product categories given in Table 1 for the intended use are addressed in this European Standard and detailed conditions for emission testing are described for them:

Table 1 — Product categories

Nr.	Product category	Description
1	Interior wall paints	This category covers all coatings and coating systems for interior surfaces with decorative and/or functional end use according to EN 13300 independent of the chemical type of binder or other specific properties. Typical substrates are e.g. mineral substrates, plasters, gypsum boards, wall papers. Intended use can be on walls, ceilings or both.
2	Interior plasters with organic binder	According to EN 15824. Intended use can be on walls, ceilings or both.
3	Interior coatings, trim paints and lacquers (small surfaces)	This category covers all coatings and coating systems for interior surfaces with decorative and/or functional end use other than described in EN 13300 and having an intended use on significantly smaller surfaces than walls, floors or ceiling. Typical examples of this category of intended use are e.g. coating systems for doors, windows, furniture or radiators. Typical substrates are e.g. wood, wood-based materials, metal and plastics. If the intended use is for large surfaces, category 4 is applicable instead of category 3.
4	Interior varnishes and wood stains (large surfaces)	This category covers all coatings and coating systems for interior surfaces with decorative and/or functional end use other than described in EN 13300 and having an intended use on large surfaces e.g. coating systems for walls, ceiling except for floor coatings. Typical substrates are e.g. wood and wood-based panels.
5	Interior floor coatings	This category covers all coatings and coating systems for interior floors with decorative end use.
6	Interior fillers	Coating material with a high proportion of extender, in powder or paste form, intended primarily to even out irregularities in all backgrounds or substrates, including masonry and coating materials, and/or to improve their surface appearance in order to prepare them to receive when required a paint or related system or a bonded cover. Intended use can be on walls, ceilings, both of them or on small surfaces for repair purpose.

Tinted products shall be tested in the same way as for white products.

6 Relevant substances emitted from coatings

For products as listed in Clause 5, the following substances are regarded as characteristic emissions and thus are covered by this European Standard. The exact target list is given by the individual test protocol.

a) VOC,

b) SVOC and

c) Formaldehyde and other very volatile aldehydes.

NOTE 1 In comparison with other products emitting substances to indoor air as construction products, furniture or electronic devices, coatings are characterised by small film thickness. In most cases, this corresponds to a rapid decay of emissions and a close relation between the content of volatile substances and their emission.

NOTE 2 This does not imply that other substances are not emitted by coatings for indoor use. If a specific test protocol requires the determination of other substances, the testing for these compounds has to be done by methods not described in this European Standard.

Other very volatile organic compounds (VVOC) can also be components of the liquid or paste product but they are considered to be emitted very rapidly from the film during drying. Typical mechanisms for chemical formation of VVOC from the dried film of coatings are not known except for aldehydes. For this reason, further VVOC emissions are not considered to be relevant for the service life of coatings.

7 Emission scenarios and reference room

7.1 Dimensions and loading factors of the reference room

The dimensions of the reference room are specified as listed below:

- floor and ceiling both measure 3 m x 4 m resulting in surface of 12 m^2;
- the walls are 2,5 m high;
- there is one door of 2 m × 0,8 m (1,6 m^2);
- there is one window of 2 m^2;
- then the total wall area (less door and window) is 31,4 m^2;
- then the total air volume is 30 m^3.

NOTE In this European Standard, the reference room dimensions and associated loading factors are normative and correspond to an usual but small living room. However, the corresponding loading factors are similar (in fact more detailed and partly slightly modified) to those given in EN ISO 16000-9.

The loading factors mentioned in Table 2 are derived and no other loading factors shall be calculated from the reference room dimension.

Table 2 — Loading factors

No.	Product categories	Loading factors m^2/m^3
1	Interior wall paints (including effect coatings, structure coatings and primers)	
	a) intended use on walls and ceilings	1,4
	b) intended use only on walls	1,0
	c) intended use only on ceilings	0,4
2	Interior plasters	
	a) intended use on walls and ceilings	1,4
	b) intended use only on walls	1,0
	c) intended use only on ceilings	0,4
3	Trim paints and lacquers (intended use on small surfaces)	0,05
4	Varnishes and wood stains (intended use on walls)	1,0
5	Floor coatings	0,4
6	Interior fillers	
	a) intended use on walls and ceilings	1,4
	b) intended use only on walls	1,0

If the above surfaces and resulting loading factors do not represent the intended use of a specific product, the nearest surface and resulting loading factor shall be applied. If a multifunction product is intended to be used in more than one of the product categories in Table 1 it shall be tested according to the product category with the highest loading factor.

7.2 Ventilation in the reference room

A ventilation rate with fresh air of 0,5 air exchange per hour (15 m^3h^{-1}) is taken as reference. In conjunction with the dimensions and climate conditions, this ventilation rate is the reference representing by convention the “general” indoor air conditions.

NOTE 1 Real ventilation rates can vary from less than 0,3 in energy tight buildings to more than 1 with continuous mechanical ventilation.

NOTE 2 In Clause 12, a calculation formula is given for recalculation of a test result (when expressed as concentration in air) to another ventilation rate than the specified one within a valid range.

7.3 Climate conditions of the reference room

The climate conditions specified in ISO 554 and in EN ISO 16000-9, i.e. 23 °C and 50 % relative humidity – shall be applied to the reference room to represent, by convention, general indoor air conditions.

7.4 Time schedule of emission determination

The time schedule starts with t_0. For coatings, this is after a preconditioning period as defined in 9.2.

The time schedule specified in EN ISO 16000-9 shall be used for emissions evaluation – i.e. short-term emissions shall be tested at three days and long-term emissions shall be tested at 28 days after t_0 (see Annex F).

At 28 days after t_0, either steady-state emissions will have been reached, or the decay of emissions will have at least slowed significantly. Such a situation can be reached much earlier for some products. In such cases, an optional shorter testing duration may be applied, if the comparability with the 28 days testing is shown in line with the requirements in 14.2.

NOTE Emissions of some SVOCs can increase after day 3.

8 Product sampling and transport

8.1 Population of the product to be considered for testing

The products within the scope of this European Standard are typically liquid or viscous preparations in their ready to use state that are delivered in cans or other airtight containers or in case of powder products in boxes or bags. Different packages of the same production batch may be considered as homogenous. Thus, a single packaging unit is usually sufficient for testing. This package shall be representative for the product placed on the market.

8.2 Sampling

8.2.1 Quantity of sample

For liquid products minimum volume: 1 l.

For paste and powder products minimum weight: 2 kg.

8.2.2 Multi-component products

In case of multi-component products, samples shall be taken from all components and the technical data sheet with information about mixing ratio and mixing procedure shall be delivered with the samples.

If dilution is mandatory for the use of the product as defined in the technical data sheet, the supplier shall provide a sample of the appropriate solvent as mentioned in the technical data sheet.

8.2.3 Additional requirements from the testing laboratory for the product sampling plan

Depending on test protocol and test facilities, there can be additional requirements on size and number of samples. The following information shall be given by the test laboratory:

- number of product laboratory sample(s) needed for the testing programme;
- when relevant, minimum and/or maximum size of product laboratory sample for the testing requirements.

8.2.4 Sampling location

Samples shall be taken as original packaged cans, containers, boxes or bags with a minimum content as described in 8.2. Products delivered in airtight containers may be taken directly from the production or from the stock as long as they are within the expiration date given by the supplier.

NOTE The emission properties of a paint film do not depend on the age of the liquid product but mainly on the age of the dried film.

If the product is delivered only in smaller sizes than those given in 8.2, the appropriate number of samples shall be taken to add up to this minimum amount.

If the product is delivered only in large containers that cannot be handled in the testing laboratory, then a representative sample shall be taken directly from a production or storage vessel with sufficient mixing facilities.

No samples shall be taken from large vessels or containers without sufficient mixing of the liquid or paste product. In the case of machine tinted products, the sample shall be provided by the supplier as ready to use tinted product.

8.2.5 Packaging

If the sample is taking in commercial cans or containers according to 8.2.4, no further packaging is needed except for mechanical protection. If samples are taken directly from production or storage vessels, the samples shall be transported in clean, airtight metal cans or laboratory bottles made of glass or polyethylene.

8.2.6 Sample description and marking

As specified in EN ISO 16000-11:2006, 4.3, with the following additional statements:

- marking of the sample shall not have any impact on emission testing;
- details of the client’s identification of the sample shall be included in the test report;
- a sampling report shall accompany the sample. An example of a sampling report is given in Annex E.

8.3 Transport

Contamination by adsorption of volatile chemicals from e.g. fuel cans, car exhausts gases, cleaners, during transport shall be avoided by proper packaging and by avoiding transport close to contamination sources such as gasoline canisters. Extreme temperatures, pressure and other physical challenges shall be avoided during storage and transport.

8.4 Chain of custody

The chain of custody form shall ensure that the product sample received in the laboratory is the same as the product sample taken in the field.

NOTE 1 It is good practice that the sampling plan specifies the completion of a chain of custody form for each sampling exercise, at the time of sampling.

NOTE 2 An example form for a chain of custody report is given in Annex C.

8.5 Dispatch of samples, time schedule

As specified in EN ISO 16000-11:2006, 4.3 and EN ISO 16000-9, Clause 15 with the following additional statements:

- the most recent product sample available from factory or stock that is ready for dispatch to the construction site or to other customers such as retailers shall be taken;
- the product sample shall be packaged, as specified in 8.2.5, as soon as possible after collection and, in any case, within the same working day;
- all samples shall be tested not later than four months after sampling.

9 Handling of product samples in the laboratory

9.1 Storage

As specified in EN ISO 16000-11:2006, 4.4, with the following additional statements:

- samples shall be protected from intensive light, exposure to chemicals and mechanical damage;
- cleaners, solvents or other volatile chemicals shall not be stored close to the sample if there is a risk of contamination that could interfere with emission testing.

9.2 Preparation of test specimen: Coatings

As specified in EN ISO 16000-11:2006, Clause 5 and Annex B, with the following additional statements:

- all coatings shall be applied in their ready to use state;
- the preparation of test specimen shall take place in a clean environment and any tools used shall be clean;
- for liquid or paste products, check and weigh the sample support before and immediately after application of the product. Then report the applied amount as the resulting difference;
- the highest recommended application amount in the technical data sheet of the product shall be chosen for preparation of the test specimen. The minimum application amount as listed in Table 3 for each product group is chosen when the maximum application amount in the technical data sheet is lower than listed in Table 3;
- the minimum number of layers corresponding to this application amount according to the technical data sheet shall be chosen;

NOTE 1 In most cases it means application of the maximum amount in one layer. Only if multiple layers are mandatory or technically necessary, the test specimen is prepared from multiple layers.

- the drying period between two layers shall be (24 ± 2) h if no longer mandatory drying periods are given by the technical information. Drying between two layers shall take place in a well-ventilated room with temperature and humidity as given in Clause 10 for the test chamber.

If the product samples consist of more than one packaging unit of the same product, the content of all packaging units shall be mixed and homogenised in a clean and inert container.

In case of a multi-component product or a powder product, mixing ratio and mixing procedure shall be done in accordance with the technical data sheet of the supplier.

If dilution of the product is mandatory, dilution ratio and dilution procedure shall be done in accordance with the technical data sheet.

All product samples shall be homogenised directly before preparation of the test specimen.

The substrate for application shall be non-porous, non-emitting and inert, such as glass and cleaned metal.

The coating shall be applied uniformly. Test specimen showing any unusual surface defects or irregularities shall not be used for the test. In case of textured coatings, the texture shall be prepared according to the technical data sheet of the supplier.

In case of wetting problems, sanding or etching of the glass surface is recommended.

Table 3 defines for each product category:

- the application methods;
- the preconditioning period of the sample;
- the minimum application amount.

If for technical reasons another application method than those defined in Table 3 is needed for a certain product, sample preparation shall be done in accordance with the technical data sheet of the supplier.

The test specimen shall be placed in the preconditioning chamber immediately after preparation of the final layer. The drying process of the final layer shall take place in the preconditioning chamber. Preconditioning period starts when the sample is put in the preconditioning chamber which can be separate from the test chamber.

NOTE 2 For coatings with high water content, the actual relative humidity in the test chamber can vary significantly from the relative humidity of the supply air during the drying process.

Table 3 — Product categories

No.	Product categories	Standard loading factors[a] m^2/m^3	Minimum application amount in ready to use state g/m^2	Application method	Pre-conditioning period (see Annex F)[b] d
The highest recommended application amount in the technical data sheet of the product shall be chosen for preparation of the test specimen. The minimum application amount for each product group is chosen when the maximum application amount is lower than listed.					
1	Interior wall paints (including effect coatings, structure coatings and primers) a) intended use on walls and ceilings b) intended use only on walls c) intended use only on ceilings	 1,4 1,0 0,4	150	Roller, brush, pouring in case of low viscosity, casting	3
2	Interior plasters a) intended use on walls and ceilings b) intended use only on walls c) intended use only on ceilings	 1,4 1,0 0,4	1 000	Trowel; for small samples on a laboratory scale: spatula or brush	3
3	Trim paints and lacquers (intended use only on small surfaces)			Roller, brush, pouring in case of low viscosity, casting	3
3.1	Solvent borne	0,05	80		
3.2	Water borne	0,05	100		
4	Varnishes and wood stains (intended use on walls)	1,00	80	Roller, brush, pouring in case of low viscosity, casting	3
5	Floor coatings	0,40	150	Roller, brush, pouring in case of low viscosity, casting	7

6	Interior Fillers			Trowel; for small samples on a laboratory scale: spatula or brush	3
	a) intended use on walls and ceilings	1,4	250		
	b) intended use only on walls	1,0	250		

NOTE 1 If a two or more layer application of a single product is recommended but not mandatory according to the technical data sheet, the total maximum application amount may be chosen in one application.

NOTE 2 Always apply the maximum amount of layers given in the data sheet.

NOTE 3 Fillers for spot repair and small surfaces do not have fixed loading factors and application amounts. Sample preparation for emission testing should be done in accordance with the technical data sheet of the individual product.

[a] Exact loading factors may vary according to Clause 10.

[b] Some products might require a longer conditioning period to reach in-use conditions as per 9.4

9.3 Preparation of test specimen: Coating systems

Emission properties of coating systems may not be calculated from the emission test results of individually tested products because the interaction of the layers cannot be predicted.

If coating systems are tested, it is recommended to follow the technical data sheet of the supplier of the system. The following details of the system shall be documented in the test report (see Clause 13):

- product names and/or sample identifiers of all components;
- application order of all layers;
- application amount of all layers;
- application method of all layers;
- drying times between the layers.

Many coatings are used in systems consisting of two or more layers of different products. Due to the fact that a very large number of combinations of different layers are possible, it is recommended to carry out emission testing only for single products.

NOTE The results of the emission test refer only to the coating system as described by the above mentioned parameters.

9.4 Preconditioning

A preconditioning period before starting the test shall be applied to enable the product to acquire properties appropriate to in use conditions as given in 9.2. The conditioning conditions (climate, ventilation, isolation from surroundings) shall be defined precisely and be in the specified ranges of the test chamber parameters. Transfer of a preconditioned test specimen into the actual test chamber is regarded as the starting time of the test (t_0).

10 Test chamber conditions

A ventilated test chamber shall be used for generating emissions from the test specimen under constant, controlled conditions. Most test chambers are smaller than the reference room and can be thought of as a scaled down model of the reference room. In general, the test chamber parameters are kept as close as possible to those specified in Clause 7 for the reference room, but deviations are accepted within a narrow range as specified below.

Generation of emissions from test specimen in a test chamber shall be performed as specified in EN ISO 16000-9 with the following additional requirements:

a) The test specimen shall be large enough to be at least as representative as the laboratory sample. Within this limit, the dimensions of test specimen shall be appropriate to the size of the test chamber and the product loading factor *L* as specified for the reference room in Table 2 (see Clause 10 i)).

b) The loading factor in the test chamber may deviate from the values specified in Table 2 within a narrow range. The loading factor shall not be below 50 % or above 200 % of the loading factor as specified in Table 2. The loading factor in the test chamber shall not exceed 2,0 m^2/m^3. In this interval, the specific emission rate will remain constant and test results given in terms of specific emission rate do not need any conversion. However, any test result given as air concentration shall be re-calculated to the loading factor in the reference room by using the formula given in Clause 12.

c) The ventilation (air exchange rate) in the test chamber may deviate from the specified value for the reference room; see 7.2. It shall not be lower than 0,25 air changes per hour and not higher than 1,5 air changes per hour. Within this interval, the specific emission rate is considered as remaining constant and test results presented in terms of specific emission rate do not need any conversion. However, any test result reported in terms of air concentration in the reference room shall be re-calculated using the formula given in Clause 12. Variation of the air change rate during the testing period shall not exceed ± 5 %, as specified in EN ISO 16000-9.

NOTE 1 While emissions from dry products are typically controlled by internal diffusion processes and are largely unaffected by ventilation (surface air velocity), the same cannot be said for “liquid” products (being wet when applied) during the drying/curing stage – i.e. while evaporation dominates the emission process. Given that building occupants are not usually present during the drying/curing phase of wet-applied products in construction works (although common for “do-it yourself” activities and redecoration), emissions testing is normally only carried out and started after the drying/curing phase. Emissions data cannot be compared directly unless all testing and preconditioning parameters, including ventilation, are identical.

d) The velocity above test specimen shall be in the range 0,1 m/s to 0,3 m/s.

NOTE 2 High air velocity and high ventilation rate might increase emission rate of less volatile substances.

e) Requirements relating to the cleanliness of the test chamber and of the supply air are defined in Clause 11 in terms of maximum acceptable background concentration in Clause 11 for the different substances analysed.

f) Temperature and relative humidity shall be registered as the average over a 15 min period. The average temperature during the entire testing period shall not deviate from the target value of 23 °C by more than ± 1 °C. Moreover, not more than 10 % of the individual 15 min average values shall deviate from the target value of 23 °C by more than ± 1 °C. The average relative humidity of the air supplied to the chamber throughout the entire testing period shall not deviate from the target value by more than ± 5 % RH. Moreover, not more than 10 % of the individual 15 min average values shall deviate from the target value of 23 °C by more than ± 5 % RH.

NOTE 3 As temperature and humidity have a significant impact on emissions these parameters cannot be varied for any type of product or test equipment without invalidating comparison of emission data.

NOTE 4 Examples are hardening or curing of reactive systems.

g) The test specimen shall stay in the test chamber the whole time during testing, i.e. until the last air sample has been collected.

NOTE 5 Moving a test specimen from the preconditioning chamber to the test chamber and vice versa after t_0 might significantly interfere with the emissions testing in term of contamination of the sample and of the chamber.

NOTE 6 For VOC of lower volatility and for SVOC, reliability of test result is relying on effective control of ventilation, climate, and wall adsorption / desorption effects, which is possible only if the sample is kept in the test chamber the whole time.

During indirect tests according to Clause 14, sample storage outside the chamber, between air sampling periods may be accepted.

h) The test chamber selected shall be large enough to accommodate a test specimen that is representative of the product in normal use. The minimum size of a test chamber shall be 20 l.

NOTE 7 The maximum size of test chambers is not limited. Experiences with existing chambers range up to 50 m^3.

i) The test specimen shall be placed in centre of test chamber as specified in EN ISO 16000-9:2006, 12.2. If efficiency of air mixing is proven to be in compliance with specifications of EN ISO 16000-9 in all compartments of the test chamber in the presence of the test portions, then the test specimen may be placed in the test chamber on the bottom or at the wall or in another manner, as long as the main surface of the test specimen is parallel to the air flow direction.

NOTE 8 Experience has shown that, with adequate mixing of test chamber air, the concentration of emitted compounds in chamber air across the test chamber usually balances out after a time corresponding to five change volumes of air.

11 Determination of vapour-phase organic compounds in test chamber air

11.1 Common requirements

A measured volume of air from the outlet of the emission test chamber is drawn at a controlled flow rate through the samplers at specified times during the emission test. Vapour-phase organic chemicals present in the chamber air are selectively trapped on the samplers as the air passes through. The type of air sampler differs depending on the compounds described in the following sections.

The sampling flow rate shall be calibrated with the sampler assembly in line, using an appropriate external calibrated metre as described in EN ISO 16017-1 and EN 1232. The total sampling flow shall not exceed 80 % of the air flow rate of the chamber.

If air sampling is to be carried out early in an emission test (within the first 72 h), the sampling duration shall show the same time before and after the target sampling time, e.g. from 71,5 h to 72,5 h.

In the following analysis, retained compounds or their derivatives are desorbed or extracted from the sampler and transferred into an analytical system where they are identified and quantified.

Duplicate samples shall be collected and the results compared.

11.2 Determination of VOCs and SVOCs in test chamber air

11.2.1 Introduction

This section specifies procedures for sampling and analysing volatile organic compounds (as specified in 3.3.1) and semi-volatile organic compounds (as specified in 3.3.3) in test chamber air. ISO 16000-6 shall be applied except for the deviations and additional requirements specified in the clauses below. The method involves pumped air sampling onto tubes packed with Tenax TA[1] sorbent and subsequent analysis by thermal desorption with gas chromatography and mass spectrometer detection (TD-GC-MS).

NOTE Annex B provides general information regarding these sampling and analysis of VVOCs in conjunction with VOCs.

11.2.2 Capillary GC column

A 5 % phenyl/95 % methyl poly siloxane capillary column shall be selected of suitable dimensions (length, diameter, film thickness) to optimise separation of the compounds of interest in the sample – i.e. VOCs with a boiling point between 69 °C and 287 °C.

NOTE Summation of specific VOCs within a particular chromatographic retention time window might be required by the material emission testing programme that is being followed. Examples of VOC summation include: Total VOC, the sum

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[1] Tenax TA is a trade name of a product supplied by Buchem BV (NL). This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the product named. Equivalent products may be used if they can be shown to lead to the same results.

of target VOCs, the "*R* value", the sum of VOCs that are not on the target list, and/or the sum of non-identified VOCs. By convention, in these cases, the retention time window of interest typically relates to components eluting from (and including) n-hexane to n-hexadecane on a non-polar, 100 % polydimethylsiloxane (PDMS) stationary phase capillary column. The column specified in this European Standard gives better (sharper) peak shapes for the more polar compounds of interest and reduces analytical uncertainty. Any change in component elution order from that seen on a PDMS column is minimal and may be ignored.

11.2.3 Tube conditioning and laboratory blank tubes

NOTE This subclause refers to blank levels on sorbent tubes that have not been used for air monitoring.

Before sampling, analyse a representative number of conditioned sorbent tubes using routine analytical parameters to ensure that the thermal desorption blank is sufficiently small. The tube blank is acceptable if no individual interfering artefact peaks exceed 2 ng and if TVOC levels do not exceed 20 ng after subtraction of non-interfering VOC artefacts. If the blank is unacceptable, recondition the tubes by desorbing them for 10 min under a 50 ml/min to 100 ml/min flow rate of inert carrier gas at a temperature ~20 °C higher than that used for analysis and then repeat the analysis. If after repeated conditioning the blank is still unacceptable, the tubes shall be re-packed.

One or two of the conditioned tubes from the batch selected for each sampling exercise shall be retained as laboratory blank tubes. These are noted. They shall then be analysed with the sampled tubes and shown to meet the performance specification detailed above (i.e. < 2 ng of any individual interfering VOC and < 20 ng total VOC after subtraction of non-interfering VOC artefacts).

Do not exceed the maximum temperature of the sorbent during tube conditioning or analysis.

11.2.4 Checking the test chamber blank

The test chamber apparatus, including supply air, shall be checked for background contamination prior to carrying out a new materials emission test as described in EN ISO 16000-9:2006, 8.2 and 12.1. The TVOC background concentration shall be lower than 20 µg/m^3. The background concentration of any single target VOC shall be lower than 2 µg/m^3.

Tenax TA tubes can generate low levels of benzene artefact, even if the tube was clean of benzene before air sampling. False-positive results might impair determination of low µg/m^3 range of benzene. It is recommended to verify any such low benzene value with an independent second test method (see Annex B and Annex F).

11.2.5 Sampling test chamber air

Ensure that the air sampling tube is at approximately the same temperature as the chamber air to prevent risk of water condensation inside the sample tube when sampling emissions.

An appropriate air sampling flow rate is in the range of 20 ml/min to 200 l/min.

NOTE VOCs ranging in volatility from n-hexane to n-hexadecane is normally quantitatively retained by a sorbent tube containing 200 mg (or 50 mm to 60 mm bed length) of Tenax TA provided air sample volumes are kept to 5 l or below.

Air samples shall be collected in duplicate, but using different pump flows such that two different volumes of air (such as 5 l and 2 l or 5 l and 1 l) are collected simultaneously (or immediately sequentially).

For determining background concentrations in the chamber or when a sample is known to be low-emitting, two duplicate 5 l volumes may be sampled to optimise sensitivity.

11.2.6 Calibration and analysis

11.2.6.1 Reporting limit, quantification limit

The quantification limit of any VOC and SVOC shall be 1 µg/m^3 as far as feasible. All quantified substances shall be reported. Substances with 5 µg/m^3 or more shall be reported with their concentrations (as calculated for the reference room in 7.1).

Traces of VOCs and SVOCs include a significantly increased uncertainty of quantification. It is recommended to report test results below 5 µg/m^3 as "< 5 µg/m^3" or "less than 5 µg/m^3".

Quantitative reporting limit of carcinogenic substances is 1 µg/m^3, as far as feasible.

11.2.6.2 Identified compounds (target and non-target compounds)

During initial system set-up, the analytical system shall be calibrated using a minimum five-point multi-level calibration and be shown to be linear (or exhibit a predictable mathematical relationship) for each target compound over a range of at least 20 (i.e. the factor between the lowest and highest mass in the range shall be at least 20). Data from this initial calibration phase shall be used to determine a relative response factor (RRF) for each compound of interest, relative to toluene.

At least one appropriate (e.g. mid-level) standard, containing toluene and the expected target compounds (or at least a set of compounds that is representative of the volatility and polarity range of the relevant target compounds), shall be run at the start of each batch of samples and be interspersed with the sample tubes – e.g. every 10th sample – as a check on RRF stability. At least three single-level standards shall be run with each sample batch. The multi-level calibration for one or more specific compounds of interest shall be repeated whenever the single level calibration for that type of compound shows unacceptable drift in actual or relative response factor since the previous multi-level calibration (see also 11.2.9).

NOTE 1 Use of an internal standard (e.g. Toluene D8 or cyclodecane) can also be helpful as a further check on analytical system stability.

Identified target compounds shall be quantified using the actual or relative response factor for each compound. Identified non-target compounds shall be quantified using the response factor for toluene (i.e. in toluene equivalents).

NOTE 2 The test result calculated and quantified with the respective calibration factor can be useful supplemental information for identified target compounds.

NOTE 3 Determining VOCs using toluene equivalents is semiquantitative, since individual compounds in the mixture might have response factors which differ widely from the toluene response factor.

Details of the response factor used to quantify identified non-target compounds shall be included in the test report (response factor for toluene or response factor for the individual compounds).

The results from duplicate samples shall be compared (see 11.2.9) taking into account the different sampled volumes.

If a regulation or a test protocol requires the data to be analysed for a specific list of target compounds then the chromatographic data shall be reviewed for identifying and quantifying any components on that list that are present above the reporting limits as specified in 11.2.6.1.

11.2.6.3 Unidentified compounds

Unidentified compounds shall be quantified using the response factor for toluene and reported as toluene equivalent level. Details about which detector was used for quantification of unknowns shall be included in the final report. The results from duplicate samples shall be compared (see 11.2.9) taking into account the different sampled volumes.

For the test report, the sum of the identified non-target compounds and the unidentified compounds shall be determined by using the toluene response factors.

11.2.7 Total volatile organic compounds (TVOC) and total semi-volatile organic compounds (TSVOC)

The sum of VOCs (TVOC, see 3.3.2) shall be determined by summing the individual concentrations of every identified (11.2.6.2) and unidentified (11.2.6.3) component eluting from a gas chromatographic column as specified in 11.2.2 between n-hexane and n-hexadecane inclusively, at a concentration above 5 µg/m^3 (calculated as specified in 11.2.6.2), all calculated as toluene equivalent.

The sum of SVOCs (TSVOC, see 3.3.4) shall be determined by summing the individual concentrations of every identified and unidentified component eluting from a gas chromatographic column as specified in 11.2.2 after n-hexadecane and not later than n-docodecane at a concentration above 5 µg/m^3.

11.2.8 Reporting of test results

Any test result shall be reported with not more than two significant figures.

EXAMPLE 125,1 and 134,9 both are expressed as 130.

NOTE This rule reflects the degree of precision that can be achieved by this testing method.

11.2.9 Quality control – Additional method performance checks required

As detailed in 11.2.3, 11.2.4, 11.2.6.1 and in the relevant parts of ISO 16000 series of standards, an appropriate level of quality control shall be employed and documented. Method performance checks shall include:

a) Single level standards interspersed with a batch of samples shall be compared with each other and with the most recent multi-level calibration. Single level standard results shall agree within 10 % and be within 10 % of the values given by the most recent multi-level calibration. If unacceptable, a new multi-level calibration shall be undertaken.

b) Results of duplicate samples shall be compared for individual compounds and for TVOC. The compound concentration determined from duplicate samples shall agree within ± 15 % of the average, after taking air sample volume into account. If there is any greater disparity, only the higher concentration shall be reported.

11.3 Determination of formaldehyde and some other volatile carbonyl compounds in test chamber air

When a determination of formaldehyde and other volatiles carbonyls compounds in the test chamber air is required, this shall be undertaken according to ISO 16000-3.

The other volatile carbonyl compounds considered above are: acetaldehyde, butyraldehyde, propionaldehyde, acetone, crotonaldehyde.

NOTE 1 It is possible to use tubes packed with Tenax TA or other sorbents and analyse by TD-GCMS (8.2) for volatile carbonyl compounds excluding formaldehyde and some other volatile aldehydes.

NOTE 2 ISO 16000-3 specifies simultaneous determination of formaldehyde and a range of other volatile aldehydes using pumped air sampling with a cartridge used to trap aldehydes by chemical reaction for subsequent analysis by high performance liquid chromatography.

11.4 Quality control – External references

Notified and accredited laboratories shall verify performance of the whole method by comparing against external references and by following the quality control requirements of ISO 16000-3:2011, Clauses 6, 9 and 11.

Use of external reference materials spiked with VOCs with known emission rate, and with known emission decay profiles, are a useful tool for evaluating the performance of the whole procedure against primary standards, provided the quality of the reference materials is known. Determination of test chamber sink effects by recovery tests using target compound sources may be applied if suitable reference materials are not available, as described in EN ISO 16000-9.

NOTE 1 Participation in round robin tests and relevant independent analytical proficiency testing schemes are useful for comparing performance against a group of laboratories.

NOTE 2 Routine laboratory checks of analytical system performance can be conveniently carried out by spiking samplers (e.g. Tenax TA tubes) with a mix of compounds that is representative (in terms of analyte mass, polarity, volatility range, etc.) of the compounds of interests.

12 Calculation of specific emission rates and expression of results at the reference room

Calculate the impact of product emissions on reference room air concentration as specified in EN ISO 16000-9, taking into account any variation in parameters (e.g. air change rate or loading factor) as allowed in Clause 7 of this European Standard.

a) The peak areas of a single compound in the chromatogram are proportional to the mass of compound injected. For each target compound, the relationship between the mass of analyte injected and the corresponding peak area is determined. The slope of the calibration curve over the linear range is the response factor of the compound analysed:

$$A_{\mathrm{St}} = b_{\mathrm{St}}\, m_{\mathrm{St}} + i_{\mathrm{St}} \qquad (1)$$

where

A_{St} is the compound peak area in the chromatogram of the standard, in area units;

b_{St} is the slope of the calibration curve (response factor);

m_{St} is the mass of compound in the standard, in nanograms;

i_{St} is the intersect of ordinates and calibration curve.

If the calibration curve crosses the origin, i_{St} is considered zero.

b) The mass of compound present in the air sample is calculated from the detector peak area using the response factor of the compound:

$$m_{\mathrm{a}} = \left(A_{\mathrm{a}} - i_{\mathrm{St}}\right)/b_{\mathrm{St}} \qquad (2)$$

where

m_{a} is the mass of compound a in the air sample, in nanograms;

A_a is the peak area of compound a in the chromatogram of the sample, in area units;

b_{St} is the slope of the calibration curve;

i_{St} is the intersect of ordinates and the calibration curve.

If the calibration curve crosses the origin, c_a is considered zero.

c) The mass concentration of the compound in the sampled air is calculated by means of the following formula:

$$c_a = (m_a - m_{ab})/V \tag{3}$$

where

c_a is the mass concentration of compound *a* in the sampled air, in micrograms per cubic metre;

m_a is the mass of compound a present in the chamber air sample, in nanograms;

m_{ab} is the mass of compound a present in the chamber blank, in nanograms;

V is the sampling volume, in litres.

d) The emission rate of the compound is calculated from the mass concentration in the sampled air by means of the following formula:

$$ER_a = c_a \, VR \tag{4}$$

where

ER_a is the emission rate of the compound *a* into air, in micrograms per hour;

VR_t is the hourly ventilation rate of test chamber, in cubic metres per hour test chamber.

e) The area specific emission rate of the compound is calculated from emission rate in the sampled air by means of the following formula:

$$SER_A = c_a \, AC_t / L_{At} \tag{5a}$$

where

SER_A is the area specific emission rate, in micrograms per square metres and hour (also called emission factor);

L_{AT} is the loading factor in test chamber, in square metres sample per cubic metres;

AC_t is the hourly air change rate of test chamber, in air changes per hour.

Specific emission rate can also be calculated as volume specific emission rate, length specific emission rate or unit specific emission rate if this reflects better the essential properties of a product:

$$SER_V = c_a \, AC_t / L_{Vt} \tag{5b}$$

$$SER_{\mathrm{L}} = c_{\mathrm{a}}\ AC_{\mathrm{t}} / L_{\mathrm{Lt}} \tag{5c}$$

$$SER_{\mathrm{U}} = c_{\mathrm{a}}\ AC_{\mathrm{t}} / L_{\mathrm{Ut}} \tag{5d}$$

where

SER_{V} is the volume specific emission rate, in micrograms per cubic metres and hour;

SER_{L} is the length specific emission rate, in micrograms per metres and hour;

SER_{U} is the unit specific emission rate, in micrograms per unit and hour;

L_{Vt} is the loading factor in test chamber, in cubic metres sample per cubic metres test chamber;

L_{Lt} is the loading factor in test chamber, in metres sample per cubic metres test chamber;

L_{Ut} is the loading factor in test chamber, in sample units per cubic metres test chamber.

f) The mass concentration of the compound in the reference room air is calculated by means of the following formula:

$$c_{\mathrm{R}} = SER_{\mathrm{A}}\ LA_{\mathrm{R}} / AC_{\mathrm{R}} \tag{6a}$$

where

LA_{R} is the loading factor in reference room, in square metres sample per cubic metres reference room;

AC_{R} is the hourly air change rate in reference room, in air changes per hour.

NOTE This calculation is based on a linear relation between the test chamber results and the reference room concentration based on reaching an equilibrium between the emission source and the indoor environment.

If specific emission rate is expressed not as area specific emission rate but as volume, length or unit specific emission rate, then of the following formulae apply:

$$c_{\mathrm{R}} = SER_{\mathrm{V}}\ L_{\mathrm{VR}} / AC_{\mathrm{R}} \tag{6b}$$

$$c_{\mathrm{R}} = SER_{\mathrm{L}}\ L_{\mathrm{LR}} / AC_{\mathrm{R}} \tag{6c}$$

$$c_{\mathrm{R}} = SER_{\mathrm{U}}\ L_{\mathrm{UR}} / AC_{\mathrm{R}} \tag{6d}$$

where

L_{VR} is the loading factor in reference room, in cubic metres sample per cubic metres reference room;

L_{LR} is the loading factor in reference room, in metres sample per cubic metres reference room;

L_{UR} is the loading factor in reference room, in sample units per cubic metres reference room.

13 Test report

13.1 General

The test report shall include the following information:

a) general reference to the relevant product samples and emission test procedure used;

b) reference to this European Standard (EN 16402).

NOTE Other information can be required under the testing programme.

13.2 Sampling

As far as available, the following shall be reported:

a) time and date of the sampling, duration of transport, batch reference;

b) key elements of the sampling plan, size and number of sample(s), and location for taking the sample(s) (see Annex E);

c) sampling conditions.

13.3 Handling of samples in the laboratory, preparation of test specimen

The test report shall include the following information:

a) description of the preparation of the test specimen with photos (taken either after preparation or after placement in the test chamber);

b) product names and/or sample identifiers of all components;

c) application order of all layers;

d) application amount of all layers;

e) application method of all layers;

f) drying times between the layers;

g) classification of the tested product according to product categories and loading factors and preconditioning period in Table 3.

13.4 Test chamber conditions

The test report shall include the following information, as far as relevant:

a) description of the test chamber and test chamber conditions.

13.5 Determination of vapour-phase organic compounds in test chamber air

The test report shall include the following information, as far as relevant:

a) details of which analytes or ranges of analytes were measured;

b) description of the analytical procedure;

c) detection limit of the analytical method;

d) performed elements of the quality control (e.g. calibration, breakthrough, laboratory blanks, desorption efficiency test, duplicates). Results of the quality control shall be reported if relevant for interpretation of test results.

13.6 Calculation of specific emission rates and expression of results in terms of air concentration in the reference room

The test report shall include the following information, as far as required:

a) Specific emission rates and respective calculated air concentration in the reference room air of:

    1) identified target compounds, provided with CAS number;

    2) identified non-target compounds, provided with CAS number;

    3) non-identified compounds;

    4) volatile carcinogens of categories CARC 1A and CARC 1B (according to Regulation (EC) No 1272/2008);

    5) R value;

    6) sum of identified non-target compounds and non identified compounds;

    7) TVOC;

    8) TSVOC.

b) Details of the uncertainty of the reported results.

14 'Indirect' methods

14.1 General

This European Standard specifies in Clause 1 to Clause 13 the reference method for emission testing of coatings. It also addresses in this Clause 14 and in Annex A “indirect” methods. The term indirect method is variously applied to mean any simplified, screening, secondary, derived or alternative method.

NOTE 1 Such “indirect” methods might be easier to apply and/or cheaper when applied in their specific field of application. An “indirect” method is in general not applicable to all products. Its specific field of application is dedicated and limited to a group of product or to a single product.

NOTE 2 The term “indirect” has been selected to underline that, instead of a direct determination by the reference method, an “indirect” method provides a result indirectly through the mandatory comparability and/or correlation to the reference method (in accordance with the purpose of the emission determination).

14.2 Requirements

As indicated in the introduction, one of the aims of this European Standard is – according to the horizontal concept specified in Mandate M/366 – that products are evaluated under comparable conditions with regard to emission into indoor air. Therefore, these “indirect” methods shall provide within their specific field of application a result comparable or correlated to the result of the reference method in accordance with the purpose of the emission determination. Guidance is given in CEN/TR 16496.

NOTE These “indirect” methods are in accordance with Mandate M/366 (see point IV-10) provided that their comparability, correlation have been demonstrated.

The requirements, especially the sampling requirements, specified for the reference method apply also for the “indirect method” unless this “indirect” method specifies different requirements, especially sampling requirements, adapted to its specific field of application. The specific and limited field of application of an “indirect” method might include requirements on raw materials, product formulation and operating parameters. In any case, with regard to the validity of the above correlation, comparability remains strictly in the field of application for which it has been established.

14.3 Examples of indirect methods

Examples of possible ”indirect” methods are given in Annex A.

Annex A
(informative)

Examples of simplified/secondary methods

A.1 General

This annex is informative and is not aimed to be exhaustive. It provides only examples in broad terms as background to Clause 14 of this European Standard where the basic requirements are specified that are to be fulfilled by any indirect method for the determination of emissions of regulated dangerous substances in indoor air from products.

If the indirect method includes a determination of organic compounds in the air of a specific test chamber, the correlation – comparability with the reference method - is easier and closer when this determination is in accordance with Clause 11.

A.2 Indirect methods relative to testing devices

A.2.1 Emission cell

The emission cell testing method is specified in EN ISO 16000-10 and may be applied for most volatile substances, such as VOC, SVOC, volatile aldehydes. An example of a commercially available emission cell is the FLEC (Field and Laboratory Emissions Cell).

A.2.2 Microchamber

Examples of methods specifying micro-chambers for fast emissions measurement include the GUT Test method for screening VOC emissions from textile floor coverings and ISO 12219-3. Micro-chamber methods may be applied for volatile and semi-volatile organic chemicals and aldehydes.

A.3 indirect methods relative to analysis

A.3.1 Thermal extraction

An example of thermal desorption testing method is specified in VDA 278 and can be applied for most volatile substances, such as VOC, SVOC, volatile aldehydes and ketones. Thermal extraction is another way of generating emissions. In this case organic compounds desorbed from the sample are swept away in a stream of inert gas and analysed using on- or off-line thermal extraction with GCMS in a similar approach to that described in Clause 9 of this European Standard.

A.3.2 Headspace / gas chromatography and in-can VOC determination

Headspace/gas chromatography and in-can testing method is specified in EN ISO 17895, and in VDA 277 and may be applied to many volatile substances, such as VOC.

A.3.3 Formaldehyde specific methods

Formaldehyde specific testing methods are:

- EN 717-1, (Chamber);

- ISO 12460-1, (Chamber);
- ISO 12460-2, (Small American chamber);
- EN 717-2, Gas-analysis (short time emission test);
- ISO 12460-3, Gas-analysis (short time emission test);
- EN 717-3, Flask test (Emission into air and caught in water);
- EN 120, Wood based panels - Determination of formaldehyde content - Extraction method called the perforator method
- ISO 12460-5, Perforator methods (Extraction);
- ASTM D 5582, (American);
- ISO 12460-4, (Japan) Dessicator tests (Emission into air and caught in water).

A.4 indirect methods relative to the evaluation of the test result

A.4.1 Content determination

Content determination methods are specified in many standards for many different substances, e.g. for VOC in EN ISO 11890 parts 1 and 2.

A.4.2 Method integrated in production monitoring

When it is required only to verify that the emission of a substance is below a certain level (e.g. the maximum of a class), it could be demonstrated by an indirect test method provided that certain manufacturing, raw material or operating parameters remain within certain domains, and the product formulation is unchanged.

A.4.3 Prediction of results at 28 days

When it is required to provide a value of the emission at the reference room, a correlation may be established between an 'indirect' measurement (e.g. the emission at 10 days) and the reference measurement (e.g. the emission at 28 days), based either on accumulated knowledge or to new experiments. The uncertainty attached to the value obtained by correlation is higher than the uncertainty of the reference value obtained by direct testing, but it can be fit for purpose in many cases. In any case, as specified in Clause 11, the validity of such correlation remains strictly in the field of application for which it has been established (raw materials, product formulation and operating parameters).

Annex B
(informative)

Information on very volatile organic compound (VVOC) testing

This informative annex provides information for test chamber air sampling and analysis of VVOC emissions in conjunction with VOC and SVOC emissions from construction products in test chambers and cells.

The purpose of this annex is to provide information and guidance. Its purpose is not to specify specific requirements since VVOCs determination would require different specific methods under the present stage of practice.

This informative Annex addresses the test chamber air sampling and analysis for determining emissions of VVOC in conjunction with VOC and SVOC emissions from construction products in test chamber.

Air sampling tubes or filters, air sampling velocity and air volume, and analysis, need to be adapted to the respective VVOC in test. In the framework of the present European Standard, relevant information and guidance can be found in:

- ISO 16000-6:2011, informative Annex D;
- EN ISO 16017-1.

Annex C
(informative)

Example form for a chain of custody report

Chain of custody report				Reference no:	
Site:			File name:		
Start:	Date:		Time		File n°
End	Date:		Time:		Person in charge:
Samplers initials:					Other specifications:

Sampling report reference no:			
Sample no start:		Total no of samples:	
Sample no end:		Laboratory:	
Sample ID:			

Handed over between:	Time:	Justification:	Conditions:

Handed over by:	Initials:			
	Signature:			
Handed over by:	Initials:			
	Signature:			

Annex D
(informative)

Benzene artefact generation on Tenax TA

Benzene can be generated as an artefact on clean Tenax TA tubes. The level of benzene is thought to be primarily linked to tube desorption temperature and is minimised if tubes are stringently conditioned at temperatures up to 320 °C, then desorbed at temperatures of 280 °C or below. However, other factors might also contribute, for example interaction with ozone or certain VOCs in the sampled air. It has not yet been possible to identify rules or correlations explaining completely under which conditions this occurs or not. If significant benzene artefact levels are generated from Tenax TA during analysis, it can interfere with benzene measurements in the low µg/m^3 range giving falsely high readings.

In the course of a robustness study of this European Standard, investigations on the generation of benzene during air sampling and analysis were performed in different laboratories with different experimental settings.

These investigations showed that some laboratories reported unexpected increase of benzene levels on Tenax TA tubes after sampling from an atmosphere known to be free of benzene. In these cases, this benzene level was higher than blank level determined from the same Tenax TA tube before air sampling.

In most (but not all) of the cases, benzene increased during air sampling in the low nanogram range, resulting in false chamber air concentrations, generally below 0,2 µg/m^3, but up to 2 µg/m^3 in other cases. This can impair accuracy of benzene determination in low levels in the µg/m^3 range.

One possible assumption is that benzene is generated on Tenax TA tubes during air sampling under certain conditions. The mechanism has not been identified. It cannot be excluded that certain VOC mixtures after adsorption undergo chemical reaction while sampling air passes over surface of Tenax TA.

As benzene test results in the low µg/m^3 range can be overestimated by artefact generation to a significant extent, it is recommended to verify low-level test results with an independent second testing method (see Annex B for additional information) before assessing a test result against any low limit value of e.g. 1 µg/m^3.

Annex E
(informative)

Example of a form for the sampling report

<table>
<tr><td colspan="2">Testing laboratory/inspection body:</td><td colspan="2">Sampler (Name, company, telephone):</td></tr>
<tr><td colspan="2">Name of the manufacturer at the place of sampling
(address/stamp):</td><td colspan="2">Manufacturer (if deviating from company's name at the place of sampling):</td></tr>
<tr><td colspan="2">Name of the product:</td><td colspan="2">Product category according to EN 16402:2013, Clause 5:</td></tr>
<tr><td colspan="2">Model/program/series:</td><td colspan="2">Batch No:</td></tr>
<tr><td colspan="2">Article No:
Misc.</td><td colspan="2">Date of batch production:</td></tr>
<tr><td rowspan="2">Sample is taken from</td><td>☐ Production
☐ Store
☐ Miscellaneous</td><td rowspan="2">How had the product been stored prior to sampling?</td><td></td></tr>
<tr><td>Place of storage:</td><td>Packing material:</td></tr>
<tr><td colspan="4">Specifics (possible negative influences by emission at the place of taking the sample, petrol emissions, solvent emissions from production, uncertainties, questions, etc.</td></tr>
<tr><td colspan="4">Confirmation
The signer herewith confirms the correctness of the data given above. The sample was selected, drawn and packed personally in accordance with the instructions for the taking of samples.</td></tr>
<tr><td>Date of sampling:</td><td colspan="3">Signature:
(Stamp)</td></tr>
</table>

Annex F
(informative)

Overview of test procedure

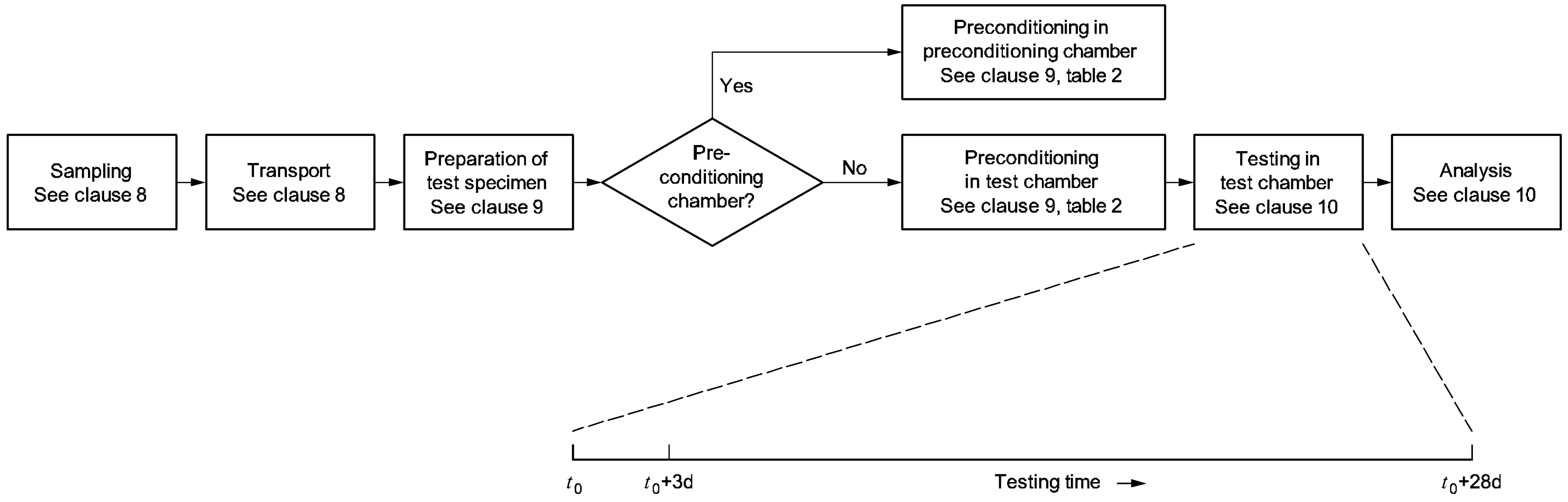

Figure F.1

Bibliography

[1] EN 120, *Wood based panels - Determination of formaldehyde content - Extraction method called the perforator method*

[2] EN 717-1, *Wood-based panels - Determination of formaldehyde release - Part 1: Formaldehyde emission by the chamber method*

[3] EN 717-2, *Wood-based panels - Determination of formaldehyde release - Part 2: Formaldehyde release by the gas analysis method*

[4] EN 717-3, *Wood-based panels - Determination of formaldehyde release - Part 3: Formaldehyde release by the flask method*

[5] ASTM D5582 *Standard test method for determining formaldehyde levels from wood products using a desiccator*

[6] EN ISO 16000-10, *Indoor air - Part 10: Determination of the emission of volatile organic compounds from building products and furnishing - Emission test cell method (ISO 16000-10)*

[7] EN ISO 17895, *Paints and varnishes - Determination of the volatile organic compound content of low-VOC emulsion paints (in-can VOC) (ISO 17895)*

[8] EN ISO 11890-1, *Paints and varnishes - Determination of volatile organic compound (VOC) content - Part 1: Difference method (ISO 11890-1)*

[9] EN ISO 11890-2, *Paints and varnishes - Determination of volatile organic compound (VOC) content - Part 2: Gas-chromatographic method (ISO 11890-2)*

[10] CEN/TR 16220, *Construction products - Assessment of release of dangerous substances - Complement to sampling*

[11] CEN/TR 16496, *Construction Products — Assessment of release of dangerous substances — Use of harmonised horizontal assessment methods*

[12] CEN/TS 16516, *Construction products — Assessment of release of dangerous substances — Determination of emissions into indoor air*

[13] ISO 12219-3, *Interior air of road vehicles — Part 3: Screening method for the determination of the emissions of volatile organic compounds from vehicle interior parts and materials — Micro-scale chamber method*

[14] ISO 12460 (all parts), *Wood-based panels — Determination of formaldehyde release*

[15] ASTM D6196-03, *Standard practice for selection of sorbents, sampling, and thermal desorption analysis procedures for volatile organic compounds in air*

[16] WILKE, O. et al., *Investigations for the improvement of the measurement of volatile organic compounds from floor coverings within the health-related evaluation of construction products*. BAM, Berlin 2009, ZP 52-5-20.49.1-1251/07

[17] OPPL, R., *Reliability of VOC emission chamber testing – progress and remaining challenges*. Gefahrstoffe — Reinhaltung der Luft 68 (2008), 83-86

[18] REPORT NO E.C.A. 13 1993. *Determination of VOCs emitted from indoor materials and products. Interlaboratory comparison of small chamber measurements*. Commission of the European Communities, Luxemburg, 1993, 90 p

[19] REPORT NO E.C.A. 16 1995. *Determination of VOCs emitted from indoor materials and products. Second interlaboratory comparison of small chamber measurements*. Commission of the European Communities, Luxemburg, 1995, 76 p

[20] IUPAC. *Compendium of Chemical terminology*, 2nd ed. (the “Gold Book”). Compiled by A.D. McNaught and A. Wilkinson, Blackwelle Scientific Publications, Oxford, UK (1997) – On-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat and B. Kosata; updates compiled by A.D. Jenkins

[21] VDA 277, *Nichtmetallische Werkstoffe der KFZ-Innenausstattung — Bestimmung der Emission organischer Verbindungen*

[22] VDA 278, *Thermal desorption analysis of organic emissions for the characterization of non-metallic materials for automobiles*

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